**White Paper on PCB and PAH Contaminated
Sediment in the Anacostia River**

DRAFT FINAL

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Executive Summary

This paper evaluates sediment contamination in the Anacostia River and proposed a means of identifying and capping hotspots to reduce risk to aquatic receptors including fish and humans who may eat those fish. It has been recognized for many years that water quality and sediment quality in the Anacostia River are highly degraded due to point source, non-point source pollution, and refuse. The problem has been made particularly troublesome because the lower reaches of the Anacostia River are tidally influenced and the slow moving water causes contaminants to settle out of the water column into bottom sediments and prevents flushing that might otherwise remove some of the contamination. Contaminated sediment can affect burrowing organisms that live within the sediment, fish that feed on those organisms, and people who consume those fish. The degree of contamination prompted public health agencies to establish advisories prohibiting fish consumption from the river. Efforts have been initiated to control many of the sources, but sediment acts as a repository for contaminants, most notably PCBs and PAHs. PCBs have been measured in sediments at concentrations between 2 μg/kg and 12,000 μg/kg, with a mean concentration of 579 μg/kg. The mean concentration exceeds a probable effects threshold for ecological resources by a factor of 2. PAHs range from 100 μg/kg to 211,300 μg/kg, with a mean concentration of 16,619 μg/kg. The mean PAH concentration exceeds TELs by about a factor of 10.

Geospatial analysis was used to identify and map sediment hotspots with concentrations exceeding the mean plus two standard deviations, which were 879 μg/kg for PCBs and 35,440 μg/kg for PAHs. Risk to ecological and human receptors associated with the sediment hotspots could be reduced by capping the hotspots with a remedial action known as sand capping. This involves placing a layer of sand or gravel over contaminated sediments, which breaks the exposure pathway between the underlying contaminated sediments and the receptors (burrowing organisms and fish) that live or feed in the surficial sediment. The combined area of the PAH and PCB hotspots is approximately 59 acres out of the study area of 628 acres or about 9 percent. Risk reduction for ecological receptors, particularly fish, based on the reduction in mean PCB and PAH concentrations are 24 and 19 percent, respectively. The reduction in the maximum concentrations are 88 and 82 percent for PCBs and PAHs. Although a formal risk assessment was not within the scope of this paper, similar reductions in risk levels for humans consuming fish from the Anacostia River are anticipated, at least for the portion of diet that is associated with fish from the river. Source control efforts at several of the larger facilities along the Anacostia River that have historically led to sediment contamination have reduced chance of recontamination of a sediment cap. However, there will likely be some recontamination of capped areas from various non-point and point sources. Additional sediment sampling will likely be required to design and implement a remedy of the type described here and monitoring will be required to document the effectiveness of the remedy. A capping remedy is likely to be most effective if combined with ongoing source control efforts focused on point source and non-point source controls so that the potential for recontamination of capped areas and other areas within the river can be minimized.

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1.0 Introduction

The Anacostia River and its watershed are a very important resource to the people living in Washington DC, Maryland, and surrounding communities (Figure 1). However, for at least three decades, it has been recognized that this resource is at risk. Water and sediment quality in the Anacostia River have been degraded by nutrient loading, toxic chemicals, and trash, resulting in adverse effects to human health and the environment.

Assessment and cleanup of the Anacostia watershed and river is challenging because of its size (176 square miles), the numerous contaminant sources, and the complexity of tidal flow. Some of the major environmental problems include nonpoint source runoff, storm water pollution, contaminated sediment, and loss of natural habitat for fish. To address these serious issues, numerous stakeholder groups have been assembled over the years to study the river system and devise approaches for cleaning up the river.

One such stakeholder group is the Anacostia Watershed Toxics Alliance (AWTA). AWTA is a voluntary coalition of over 25 groups, agencies, and institutions, convened by the EPA in 1999 to investigate toxic substances that present an unacceptable risk to human health and the environment, and develop and implement a comprehensive contaminated sediment management strategy. A major impetus for the group's creation was the listing of the Washington Naval Shipyard on the National Priorities List in conjunction with several other sites in other remedial programs. The goal was to comprehensively assess contaminated sediments in the river as part of the remedial investigation process.

AWTA developed a three phase approach for addressing sediment contamination. Phase 1 used existing data and information to perform initial human health and ecological risk assessments, and identified the major gaps in knowledge required to formulate decisions about remedies. This phase was completed during the first year and the Phase 1 Report titled *Interpretive Summary of Existing Data* was published in June 2000. Phase 2 studies were conducted to fill in significant data gaps, and an overall conceptual model of the river (including hydrodynamic models and sediment transport analysis) was developed. With this fundamental understanding of river dynamics, and existing contamination, potential remedies to address risks were identified. The information was presented in a document entitled *Charting a Course Toward Restoration: A Toxic Chemical Management Strategy for the Anacostia River* (AWTA 2000). Phase 3 is the ongoing implementation phase with the objective of designing and conducting reasonable remedial actions, developing effective monitoring strategies focused on contamination issues, and documenting restoration success.

In addition to articulating the Anacostia Watershed Toxics Alliance's (AWTA) preliminary position on how to address these contaminated areas, this paper is intended to communicate: 1) the approximate location of the contaminated sediment hotspots; 2) potential contributing sources; 3) an initial scope of a potential remedial action; and 4) estimated remediation costs. This paper derives the bulk of its information from the Anacostia Watershed Toxics Alliance (AWTA) Contaminants Management Plan and Conceptual Model, the final 18-month Anacostia capping study (Horne, 2007), and subsequent spatial analyses performed by NOAA using the GIS-based Anacostia

Watershed Database and Mapping Project. The approach used to identify the hotspots incorporates information and integrates an understanding of the river system (i.e., hydrodynamics, sediment transport, contaminant fate and transport, etc.) as developed through AWTA's conceptual model.

1.1   Indicator Chemicals

A number of toxic chemicals have been identified in sediment samples collected in the Anacostia River, but two chemical groups (indicator chemicals) were selected for detailed study in this paper because of their toxicity and relatively widespread distribution: polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs). DC issued a fish advisory for the Anacostia River in 1989 and the Agency for Toxic Substances and Disease Registry (ATSDR) performed a health consultation demonstrating that PCB levels are elevated to the extent that consumption of fish poses a risk to recreational fisherman (ATSDR, 1991). Contaminated fish may also pose a risk to piscivorous mammals and birds such as osprey. PCBs and PAHs are hydrophobic and lipophilic compounds, indicating that they partition rapidly from water to organic material (e.g., sediment, fat tissue, soil, etc), which can serve as a reservoir where they have the potential to persist for extended periods of time. For instance, although PCBs were banned in 1978, they can persist for many years or even decades, and are still found in abundance in the sediment of the Anacostia River.

PCBs were manufactured for their chemical and thermal stability and used as liquid insulators in electrical equipment. They were widely used in electrical transformers and also as hydraulic fluids. The molecular structure of PCBs consists of two linked six-carbon phenyl rings. Each of the five open carbon molecules in the rings has the potential for a single chlorine atom bond. This produces a theoretical total of 209 potential variations, which are generally termed "congeners." Persistence and stability in the environment, and the toxicological modes of action, are related to the number of chlorine atoms and their relative positions. Many of the products containing PCBs had distinctive patterns in the congeners and sources can sometimes be determined from patterns found in environmental samples. Due to the lipophilic nature of PCBs, they are readily bio-accumulated in the fatty tissues of aquatic organisms and pose the potential for biomagnifications and disruption of food web dynamics. Consequently, PCBs present a risk to wildlife (such as osprey) and humans.

PAHs are commonly found in oils and oil products, and are generated through the combustion of almost any organic material, including coal and wood. The molecular structure of PAHs consists of six-sided benzene rings, linked in a pattern similar to that observed in honeybee combs. The number and pattern of the assembled benzene rings, along with the attachment of other atoms or molecules determines the character and toxicity of these molecules. Patterns in the abundance of the various molecules can be linked to the products used in combustion, thus helping to identify potential sources. PAHs and their metabolites have been linked to excess tumor rates in bottom-feeding fish like the brown bullhead. PAHs can also be directly toxic to and can accumulate in sediment dwelling organisms that are a food source for fish.

1.2   Draft Remedial Strategy

AWTA recognizes that the Anacostia Watershed is an extremely complicated system which has been impacted by a variety of historical and ongoing sources of toxic chemicals. Contaminated sediments are relatively widespread within the river, however, a review of historical sampling data indicated that chemical concentrations are particularly high in certain areas that can be considered "hotspots." This pattern suggests that there may be utility in evaluating a remedial strategy focusing on hotspots. An advantage of such an approach is that it may be possible to substantially reduce sediment concentrations in hotspots at a lower cost than dealing with the entire area of contaminated sediments. This concept is sometimes framed as trying to achieve the greatest "bang for the buck." A number of important issues are raised by this approach and are addressed to varying degrees in this paper:

- Are ongoing sources of contaminants controlled? If not, then remedial actions may be premature and limited financial resources may be wasted. This question is partially answered in section 1.3 but should be included in future, more detailed studies and plans.

- How is the threshold concentration identifying hotspots defined? The concentration can be risk-based or statistically determined as explained later. The latter approach is taken for simplicity in this paper and risk-based concentrations are mentioned as a point of reference.

AWTA recognizes that comprehensive efforts will be required to return sediment and water quality to health. Efforts will likely include point and nonpoint source control, active remediation (capping or dredging) of sediment with highly elevated concentrations, and possibly natural recovery of sediments with moderately elevated concentrations. These terms are explained later in the paper.

1.3   Sources of Contamination

Sources of contamination to the mainstem Anacostia River include releases from individual facilities or waste sites along the river, storm water discharges, combined sewer overflows, nonpoint source runoff, atmospheric deposition, and input from tributaries. The nature of the source (point source vs. nonpoint source) and the transport mechanism within the river have an impact on the distribution of contaminants within the river. For example, contaminated sediments from point sources would likely be located adjacent to the facility although over time the contaminants may move downstream if there is enough energy in the river to transport the sediment. Previous work suggests that the upstream portion of the Anacostia River is generally erosional and the downstream portion, near the confluence with the Potomac River is generally depositional (Hill et al, 2000). The zone in between is likely to be transitional between erosional and depositional depending on the lateral position within the river (inside or outside of a bend.)

EPA has indentified four sites along the Anacostia River that may be point sources of either PCBs, PAHs or both. These sites are describes below.

Pepco Benning Road

The Pepco Benning facility is located at 3400 Benning Road NE, Washington DC. The site is bordered by residential areas to the east, commercial areas to the south, and the Anacostia River to the west. Pepco Energy Incorporated uses the 77 acre site to manage operations and maintain equipment associated with their electrical distribution system. Several releases to the environment have occurred between 1987-2003 resulting from spills of contaminated oil or leaking equipment. Pepco has completed five cleanups of contaminated soil and other materials in order to address these areas and installed Low Impact Development (LIDS) rain gardens in order to reduce runoff from the site. EPA has conducted several environmental investigations in the past at the facility and recently completed sampling of soil and sediments at the site in September 2008 as part of Site Investigation (SI) efforts.

Poplar Point

The 110 acre parcel known as Poplar Point is part of a land transfer from the National Park Service (NPS) to DC. Portions of the site are contaminated from past use by DC, the Architect of the Capitol and the Navy. Past studies have found contamination of soil, sediment, groundwater, and surface water with a wide variety of chemicals including metals, pesticides, petroleum products and solvents. The National Park Service and DDOE is currently coordinating in an effort to develop a plan for determining the nature and extent of the contamination at the site, in order to determine if clean up actions are needed.

Kenilworth Landfill

The Kenilworth landfill is a 50 acre site that is located south of the Watts Branch and east of the Anacostia River. The Kenilworth Landfill was used by DC as a municipal dump from the 1950's to the 1970's. During this period the landfill extended into the Anacostia River and no barriers were constructed to prevent migration of wastes mixed with soil into the water. In the 1970's the National Park Service placed a vegetated cap on the landfill and converted the area into a park. From 1996 to 1997 construction debris was disposed of in an area west of Dean Avenue. NPS removed some of the construction debris, graded, and planted vegetation in this area. NPS completed a Remedial Investigation/Feasibility Study (RI/FS) in 2002 which documented the nature and extent of the contamination and proposed a remedy for cleanup. Sampling results indicated that fill materials had elevated levels of PCBs, PAHs, arsenic, and lead. NPS proposed installing a cap to prevent contact with the soil along with institutional controls and monitoring. Additionally, NPS has installed riprap to prevent erosion of soils originating from the contaminated areas.

Washington Gas and Light Company

Washington Gas and Light Company (Washington Gas) site is comprised of two parcels, the 4.2 acre NPS parcel which was transferred to DC in December 2008, and the 11.4 acre East Station property. The property is located at 1240 12th Street in Southeast Washington situated next to the Anacostia

River. The Washington Navy Yard is located just south of the site. The East Station property is the location of the former manufactured gas plant which operated from 1888 to 1948. Several environmental studies were conducted following the closure of the gas manufacturing plant in 1983. Sampling results from these studies indicated that soil and groundwater on the site were found to be contaminated with waste byproducts of coal tar wastes such as PAHs, volatile organic compounds (VOCs), and metals such as beryllium, arsenic, and lead. Washington Gas initiated treatment of the groundwater using an interceptor trench, recovery wells, and a groundwater treatment system to remediate and prevent migration of site related contaminants. The National Park Service (NPS) completed a Feasibility Study (FS) which proposed excavating and disposing of soils contaminated with coal gas wastes which posed risk to park visitors and onsite workers. EPA reviewed the Feasibility Study (FS) and recommended that contaminated sediments be addressed as a part of the remedy. The NPS ROD specified that Washington Gas would address river sediments as part of the remedy. Washington Gas Light has developed a work plan for a sediment investigation and has submitted the document to EPA, DDOE, and NPS for review and comment.

Pepco Benning Road, Poplar Point, Kenilworth Landfill and Washington Gas Light sites have been investigated and shown to be contaminated with PCBs and/or PAHs. While some of these sites have undergone a remedial action there is a potential for historical contamination to have contributed to the PAH and PCB hot spots. As described above, significant source control efforts at several of the major facilities along the river have been implemented or are planned. Additionally, there are ongoing efforts to implement non-point source controls including LID techniques. Therefore, it is anticipated that ongoing or future recontamination will occur in the future to a lesser degree than has occurred in the past.

1.4   Need for Action

Current monitoring efforts (e.g., permit-based monitoring) are insufficient to characterize ongoing PCB and PAH loadings at a localized scale. The TAM/WASP model incorporated into the conceptual model predicts surface water and sediment concentrations except in hotspot areas where local sources are not well characterized by the model. There is also no long-term monitoring program that assesses the effectiveness of source control actions within the watershed. Natural attenuation of hotspot sediments by deposition of cleaner sediment on top is expected to take 20+ years, and that is only if effective source control actions are taken throughout the watershed. Given the 20+ year recovery process to abate ecological and human health risks, sediment hot spot areas have been identified for potential active remediation to achieve risk reduction more quickly.

2.0　Methodology

2.1　Evaluation of Chemistry Data

The evaluation in this paper focuses on samples collected in the top 10 centimeters (cm) that were analyzed for PCBs or PAHs. Data from 13 studies were obtained and extracted from NOAA's Query Manager database (NOAA, 2008).　One study conducted by the Academy of Natural Sciences (ANS) was relatively comprehensive (ANS, 2000), while the other studies tended to focus on a specific geographic area or were intended to answer a limited scientific question. The other studies used in this paper were conducted between 1990 and 2003, using a variety of sampling protocols and analytical methodologies (Table 1).　For these reasons, the ANS 2000 data, which were collected synoptically using consistent protocols, were evaluated as a single dataset for some of the evaluations in this paper.　Additionally, the larger dataset (ANS plus the other 12 studies) was considered in total, recognizing the limitations and uncertainties that existed when using somewhat dissimilar data. Figure 2 shows the locations of the sediments samples that were used in this paper.

Table 1. Sediment Sampling Studies in the Anacostia River

Study Description	Date	Number of Samples
EMAP- Chesapeake Bay	1990	1
Bolling AFB – SW Corner Landfill	1992	5
Potomac and Anacostia Sediment Study	1992	12
Washington Navy Yard	1995	7
US Fish and Wildlife Service- Mason Neck	1996	3
Washington Gas- East Station Project	1996	8
DC Sediment Core Analysis	1997	6
USACE Federal Navigation Channel	1998	4
GSA SE Federal Center	1999	24
Washington Navy Yard RI	1999	33
Ambient Toxics Chesapeake Bay	2000	6
US Fish and Wildlife Service Bioavailability	2000	4
Academy of Natural Sciences	2000	125
Active Capping Study	2003	77

Total PCBs used in this paper were calculated as either the sum of the aroclors or the sum of the congeners depending on the analytical method used by the original investigators. It should be recognized that these analytical methods are not identical, which may introduce inaccuracy into the analysis. For PAHs, the value used was the sum of the low molecular weight PAHs and the high molecular weight PAHs. These data were imported into ARCGIS for mapping and spatial analysis purposes. Table 2 shows the number of sample points used for each group of chemicals. A polygon

of the river bank was used to clip data points that fell outside of the river corridor. Next, an inverse-distance weighting algorithm was used to interpolate the point data onto a 10 meter (m) by 10 m square grid, within a model domain of 628 acres. Table 3 shows statistics calculated from the samples points for PCBs and PAHs.

Figure 3 shows the distribution of PCBs within the Anacostia River sediments using the ANS 2000 data and all 13 studies. Figure 4 shows the distribution of PAHs within the Anacostia River sediments using the ANS 2000 data and all 13 studies. Spatial statistics from the grids, including minimum, maximum, mean and standard deviation, were then calculated from the grid, as summarized in Table 4.

Table 2. Number of Sediment Samples Used in the Analysis

Contaminant	All studies (13 surveys)			ANS 2000 survey only		
	All samples	Excluded*	Samples used	All samples	Excluded*	Samples used
PCBs	383	88	**295**	133	9	**124**
PAHs	424	110	**314**	134	9	**125**

*Samples falling outside the Anacostia River corridor including samples from the Potomac River were excluded from the analysis

Table 3. Summary Statistics for PCBs and PAHs (Sample Data)

Study	Number of Samples	Minimum	Mean	Maximum	Standard Deviation
PCBs [1]					
ANS 2000	124	2	181	1,643	171
All Studies	295	ND	579	12,000	1,091
PAHs [1]					
ANS 2000	125	495	11,742	56,330	8,737
All Studies	314	100	16,619	211,300	22,453

[1] Values reported in micrograms per kilogram (µg/kg).

2.2   Preliminary Identification of Areas Potentially Requiring Active Remediation

This section presents a preliminary identification of river locations recommended for focused feasibility studies and potential active remediation. These areas pose the greatest risk to benthic organisms higher trophic level ecological receptors and human health due to their elevated PAH and PCB sediment concentrations. A spatial evaluation of contaminant concentrations was performed using the GIS-based Anacostia Watershed Project.

Table 4. Summary Statistics for PCBs and PAHs (Gridded Data)

Study	Minimum	Mean	Maximum	Standard Deviation
PCBs [1]				
ANS 2000	2	189	1,635	123
All Studies	ND	297	7,496	291
PAHs [1]				
ANS 2000	500	10,720	56,308	6,190
All Studies	357	11,584	200,683	11,928

[1] Values reported in micrograms per kilogram (µg/kg).

The identification of areas contaminated to such a degree that they pose unacceptable risk was initially estimated by comparison of sediment chemistry to benchmarks for protection of ecological resources. For PCBs, the benchmarks applied were the freshwater threshold effect levels and probable effect levels (TELs/PELs; 34 and 277 µg/kg respectively) that are indicative of a low and high probability of risk to the benthic community, respectively. These values draw upon synoptic chemical analyses with observations not only from bioassays with several freshwater species, but also from observations of several benthic community metrics. Because of the broad basis for their derivation, these values are considered more robust than benchmarks derived from single measurement endpoints. For PCBs, guidelines for sediment have yet to be established for the protection of fish based on bioaccumulation in the food web. Values assessed by Paige Doelling-Brown in her food web model were also evaluated geographically (Doelling-Brown, 2001). She estimated bioaccumulation at the average PCB concentration of 286 µg/kg and at half of that value.

PAHs are metabolized by most vertebrates (fish for example), so tissue residues are not good indicators for risk. So for PAHs, two benchmarks were used:

- A freshwater sediment TEL of 1,700 µg/kg, which is protective of the benthic community, and

- A sediment guideline of 2,000 µg/kg, which is a risk threshold for benthic fish.

An initial screening indicates that PAHs in sediments exceed the benchmarks throughout the entire river. Also, PCBs throughout the entire river exceeded the TEL, suggesting the potential for toxicity. Although biological observations throughout the extent of the areas that exceeded benchmarks seem to corroborate these predictions, these evaluations were not helpful for providing priorities. Therefore, additional evaluations were conducted to help determine those areas most likely in need of active remediation. A preliminary spatial evaluation of contaminant data was conducted to identify those areas that indicated the greatest degree of contamination.

As an alternative to using ecologically-based screening values, a statistical approach for defining hotspots was developed to define the threshold for a hotspot. Figure 5 is a histogram of the PCB sample results for the ANS 2000 and complete data sets. Figure 6 is a histogram of the PAH sample results for the ANS 2000 and complete data sets. The value selected for a hotspot threshold was the mean plus two standard deviations. For example, the hot spot threshold for PCBs (all data) was defined as the mean (297 µg/kg) plus two standard deviations (2 x 291 µg/kg), or 879 µg/kg. The hot spot threshold for PAHs (all data) was defined as the mean (11,584 µg/kg) plus two standard deviations (2 x 11,928 µg/kg), or 35,440 µg/kg.

 Figure 7 shows the hotspots for PCBs and PAHs, which would be capped under the approach suggested in this paper. Table 5 shows the mean concentration in the sediments before and after placing the hypothetical cap over the hotspots. These were calculated by assuming that the concentration of PCBs and PAHs in the cap material would be zero. Using the ANS 2000 data only, the reduction in mean concentrations for PCBs and PAHs are 10% and 11%, respectively. Using all of the data, the reduction in mean concentrations for PCBs and PAHs increases to 24% and 19%, respectively. The greater effectiveness is at least in part a reflection that several of the studies that supplement the ANS 2000 study were intended to investigate specific source areas. Consequently, the hotspots are better defined using the larger data set. The hotspot capping approach would reduce the maximum concentrations to the capping threshold. For example, using all of the PCB data the original maximum of 7,496 µg/kg would be reduced to 879 µg/kg, an 88 percent reduction. The PAH maximum would be reduced from 200,683 µg/kg to 35,440 µg/kg, an 82 percent reduction.

Table 5. Calculated Reduction in Mean Concentration by Capping Hotspots

Chemical Class	Mean Concentration (before)	Mean Concentration (after capping)	Percent Reduction in Mean
PCBs (ANS 2000)	189	169	10%
PCBs (All Studies)	297	225	24%
PAHs (ANS 2000)	10,720	9,581	11%
PAHs (All Studies)	11,584	9,352	19%

Further sampling should be conducted to characterize these locations at a level suitable for performing a focused FS. Site-specific sediment stability should be evaluated to confirm that capping would provide an effective, long term remedy. For instance, erosional areas are not considered amenable to placement of a standard cap in since it may not provide long-term protection in these areas.

2.3 Remedy Evaluation

Remedial actions for contaminated sediment generally include dredging, capping, natural recovery, or a combination of these approaches. A FS report for a contaminated sediment project typically considers all of these technologies and evaluates them against criteria including short and long-term effectiveness, implementability, permanence, and cost. Estimating the cost of dredging requires knowledge of the depth of contaminated sediments as well as the aerial extent. Additionally, it is important that ongoing sources of contamination have been eliminated or controlled to an acceptable degree. Finally, the dynamics of sediment transport in the system need to be understood to evaluate the type of material (grain size) required for a cap. In the absence of such detailed information, for the purposes of this white paper it is assumed that an aggregate cap (sand or gravel) would be placed over hotspot areas. This approach allows consideration of remedial effectiveness based on area alone. Calculating the decrease in concentrations can be viewed as an approximate surrogate for risk reduction because the majority of chemical exposure related to sediments is associated with surficial sediments. This is true because the inputs for an ecological risk assessment include either a central tendency value, such as the mean concentration, or a reasonable maximum exposure, which is characterized by values near the upper end of the distribution of a data set, such as the 90th percentile.

Unit costs for capping materials taken from the Anacostia River Active Capping Pilot Study are provided in Table 6 (Horne, 2005). As indicated in the subject report, the values in Table 6 do not

include mobilization or placement costs because the cost expended in the pilot study are unlikely to be representative of the cost that would be incurred in a full scale capping project. The last column in Table 6 includes an escalation factor of 34 percent to account for inflation in the time between the original study and 2009 (USACE, 2008).

Table 6. - Capping Technology Costs on a Unit Cost Basis

Cap Type	Cap Material Cost (Horne, 2005)	Cap Material Cost Escalated to 2009 [1]
12" Sand Cap	$9/yd²	$12/ yd²
6" Sand Cap	$9/yd²	$12/ yd²
Aquablok	$31/yd²	$41/ yd²
Coke Breeze	$15/yd²	$20/ yd²
Apatite	$42/yd²	$56/ yd²

[1]   Unit costs were escalated using factors from USACE, 2008

2.4   Risk Reduction Associated with Capping Hot Spots

Capping sediments with the highest concentrations of PCBs and PAHs will reduce the risk to ecological receptors such as fish as well as humans who consume fish. Calculating the amount of risk reduction for either ecological or human receptors is complicated because it depends on hard to measure factors such as the home-range of various species and the fraction of food that a particular human population consumes from the Anacostia River. It is useful to consider the home range of different fish species to bracket the range of possible exposures. If a fish species has a very limited home range with respect to a capped area then the chemical load in specific fish that spend their lives in that area may be quite low. However, there may be other individuals of that same species that spend their lives in adjacent, uncapped areas. (If there is an equal likelihood of individual fish being in either area, the resultant risk for that species can be approximated by the risk associated with the average sediment post-capping concentrations.) On the other end of the spectrum are fish with a large home range. If their home range is larger than the lower Anacostia study area, then the risk reduction to these fish would be proportional to the amount of their life span spent in the study area, weighted by the concentration reduction in the study area. Table 7 shows the estimated reduction in average and maximum risk for ecological and human receptors that might be realized by capping the identified hotspots. The values in Table 7 were calculated that the average risk reduction is equal to the reduction in mean concentration and that the maximum

risk is associated with the maximum sediment concentration before or after capping. The risk reduction for human receptors would be proportional to the assumed amount of fish consumed from the Anacostia River. For example, capping hotspots would offer considerably more risk reduction to someone who regularly consumed fish from the river than to another person who rarely consumed fish from the river.

The hotspot remediation project is a possible first phase of a holistic and integrated management plan designed to rehabilitate the Anacostia Watershed. However, more detailed studies would be required to carry out a capping project. Without preference to a specific regulatory framework it would be necessary to better define the extent of the hotspots by collecting and analyzing sediment samples, prepare a FS for the contaminated sediments, complete a remedial design, and implement remedial actions. Table 8 provides order of magnitude costs for these elements of the project, based on experience with similar projects. The sum of the costs shown here is on the order of $6 to $8 million dollars. This does not include dredging or source control, which are likely to be required in some areas to prevent recontamination.

Table 7. Estimated Risk Reduction for Ecological and Human Receptors by Capping Hotspots

Chemical Class	Percent Reduction in Average Risk	Percent Reduction in Maximum Risk
PCBs (ANS 2000)	10%	73%
PCBs (All Studies)	24%	88%
PAHs (ANS 2000)	11%	59%
PAHs (All Studies)	19%	82%

Table 8. Order of Magnitude Costs for Capping and Associated Activities.

Work Element	Order of Magnitude Cost
Sediment Sampling	$300,000 to $500,000
Feasibility Study	$80,000 to $150,000
Remedial Design	$70,000 to $130,000
Remedial Action (50 to 60 acre sand cap)	$3,000,000 to $5,000,000
Monitoring	$200,000/yr for 10 years
Total	$6 million - $8 million

3.0 Summary and Conclusions

This paper evaluated sediment contamination in the Anacostia River and proposed a means of identifying and capping hotspots to reduce risk to aquatic receptors including fish and humans who may eat those fish. It has been recognized for many years that water quality and sediment quality in the Anacostia River are highly degraded due to point source, non-point source pollution, and refuse. The degree of contamination has resulted in advisories prohibiting fish consumption from the river. Efforts have been initiated to control many of the sources, but sediment acts as a repository for contaminants, most notably PCBs and PAHs. PCBs have been measured in sediments at concentrations between 2 μg/kg and 12,000 μg/kg, with a mean concentration of 579 μg/kg. The mean concentration exceeds a probable effects threshold for ecological resources by a factor of 2. PAHs range from 100 μg/kg to 211,300 μg/kg, with a mean concentration of 16,619 μg/kg. The mean PAH concentration exceeds TELs by about a factor of 10. Geospatial analysis was used to identify hotspots with concentrations exceeding the mean plus two standard deviations, which were 879 μg/kg for PCBs and 35,440 μg/kg for PAHs.

Risk associated with the sediment hotspots could be reduced by capping those areas with a sand cap. The combined area of the PAH and PCB hotspots is approximately 59 acres out of the study area of 628 acres or about 9 percent. Risk reduction based on the reduction in mean PCB and PAH concentrations are 24 and 19 percent, respectively. The reduction in the maximum concentrations are 88 and 82 percent for PCBs and PAHs. Source control efforts at several of the larger facilities along the Anacostia River that have historically led to sediment contamination have reduced chance of recontamination of a sediment cap. However, there will likely be some recontamination of capped areas from various non-point and point sources.

Additionally, future restoration efforts should include restoration of the natural benthic substrate in the hotspot areas, stabilization of the riparian banks with native vegetation, employing LID (Low Impact Development) technologies in developed areas, and the restoration of wetlands. Best Management Practices such as LID techniques, wetland restoration and stream bank stabilization serve a vital function in reducing erosion, and intercepting runoff of urban contaminants, thus preventing the reintroduction of contaminants after the remediation has occurred. Once the hotspot cleanup is completed, natural substrate should be reintroduced to the site to encourage recolonization of indigenous benthic organisms. The final phases of the proposed ATWA strategy would ultimately focus on monitoring the results of the watershed restoration efforts. Monitoring activities would typically involve obtaining post remediation confirmation sampling, collecting water quality data, and conducting riparian habitat assessments and fish and benthic macro-invertebrate surveys to assess the effectiveness of the watershed management efforts.

4.0 References

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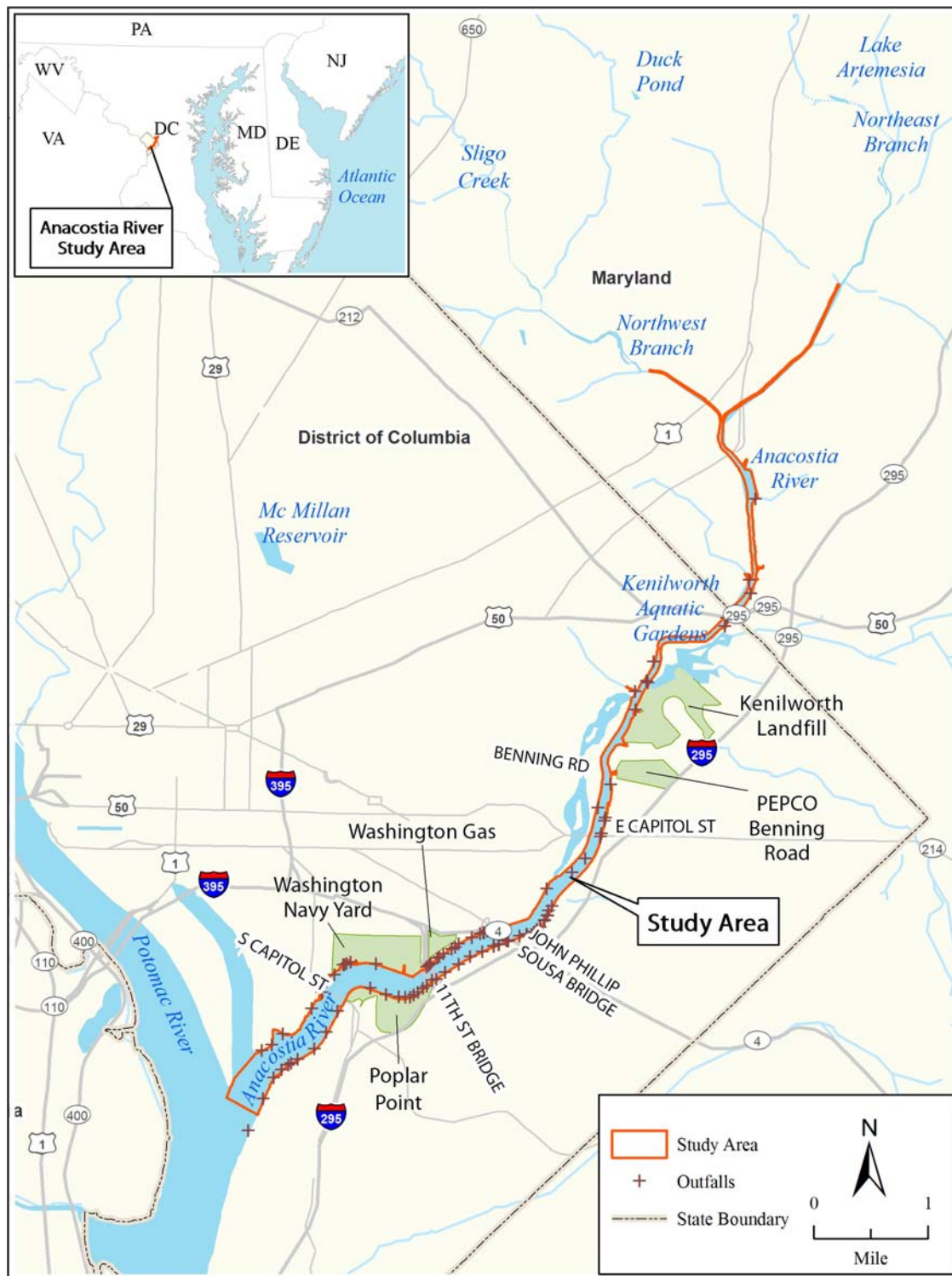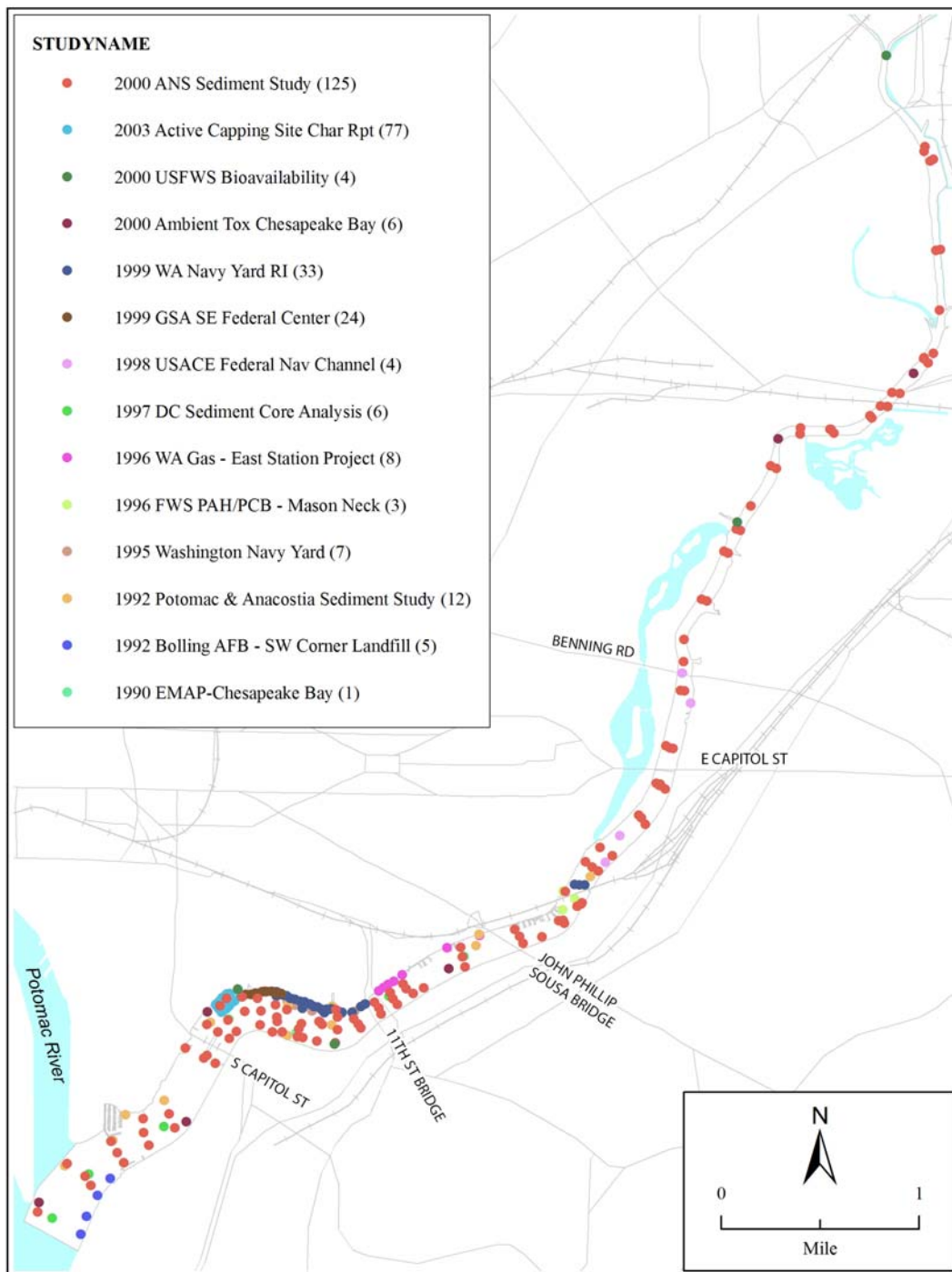
Figures

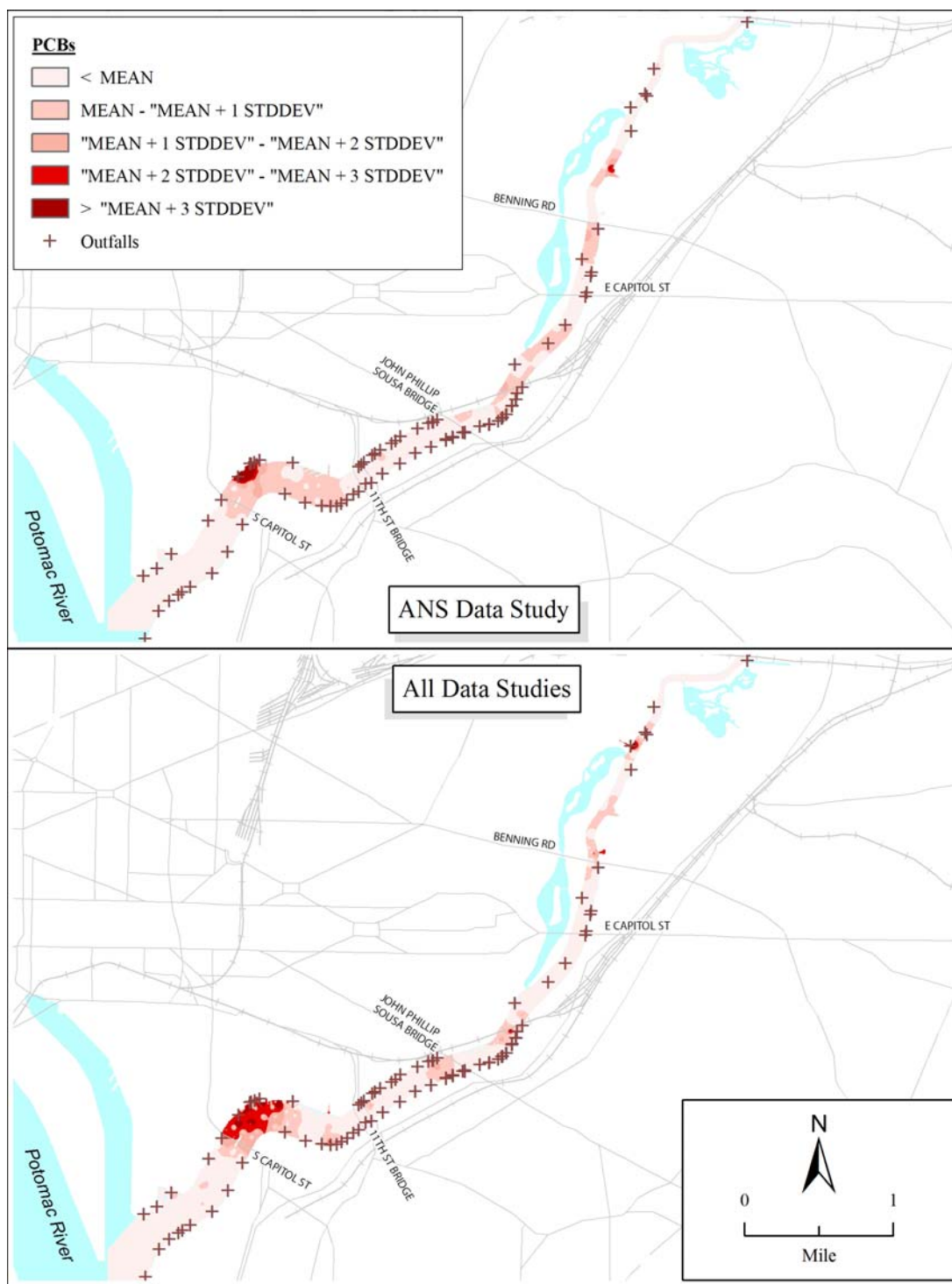**Figure 1 Site Location Map**

Figure 2 Sample Location Map
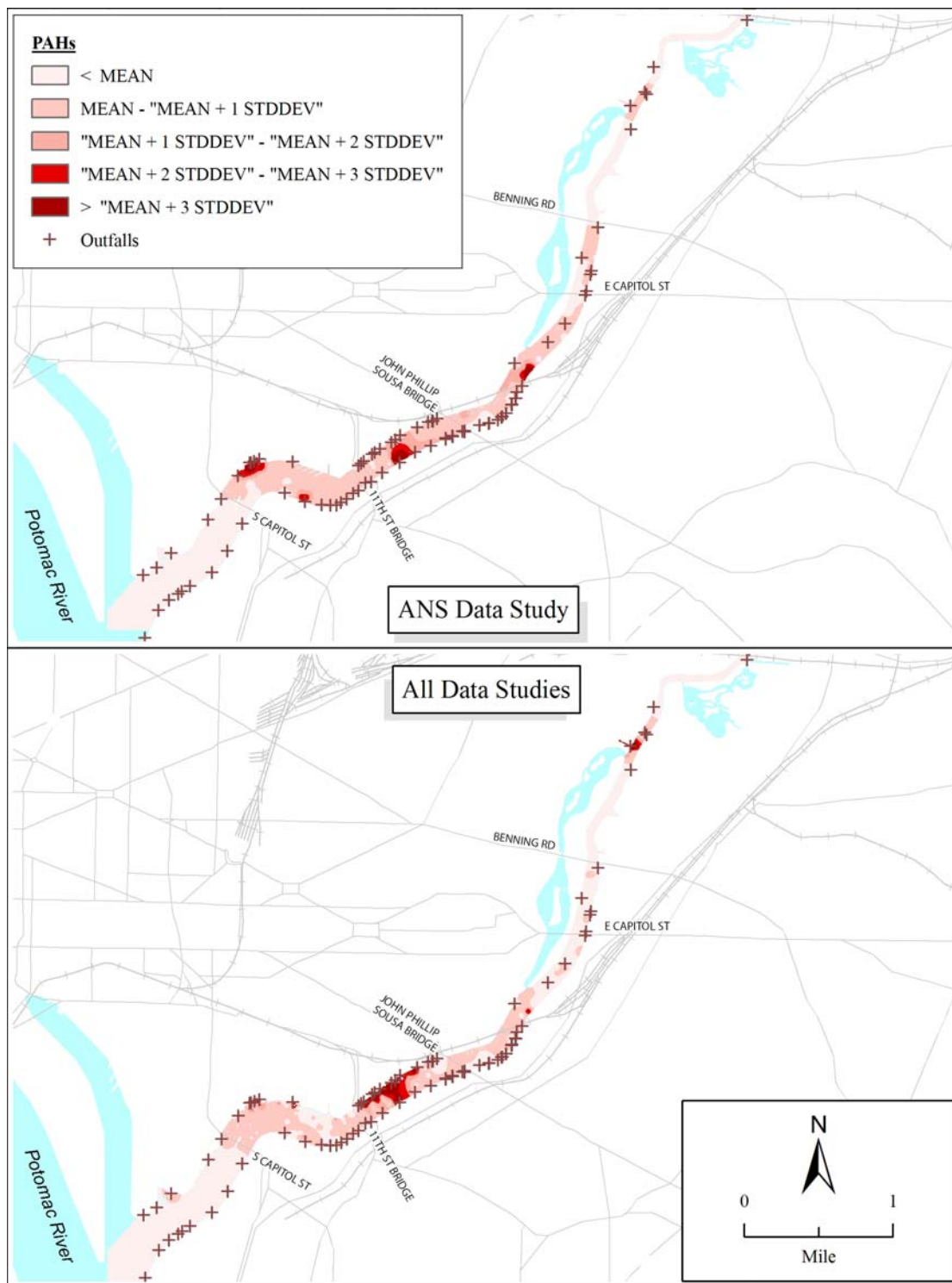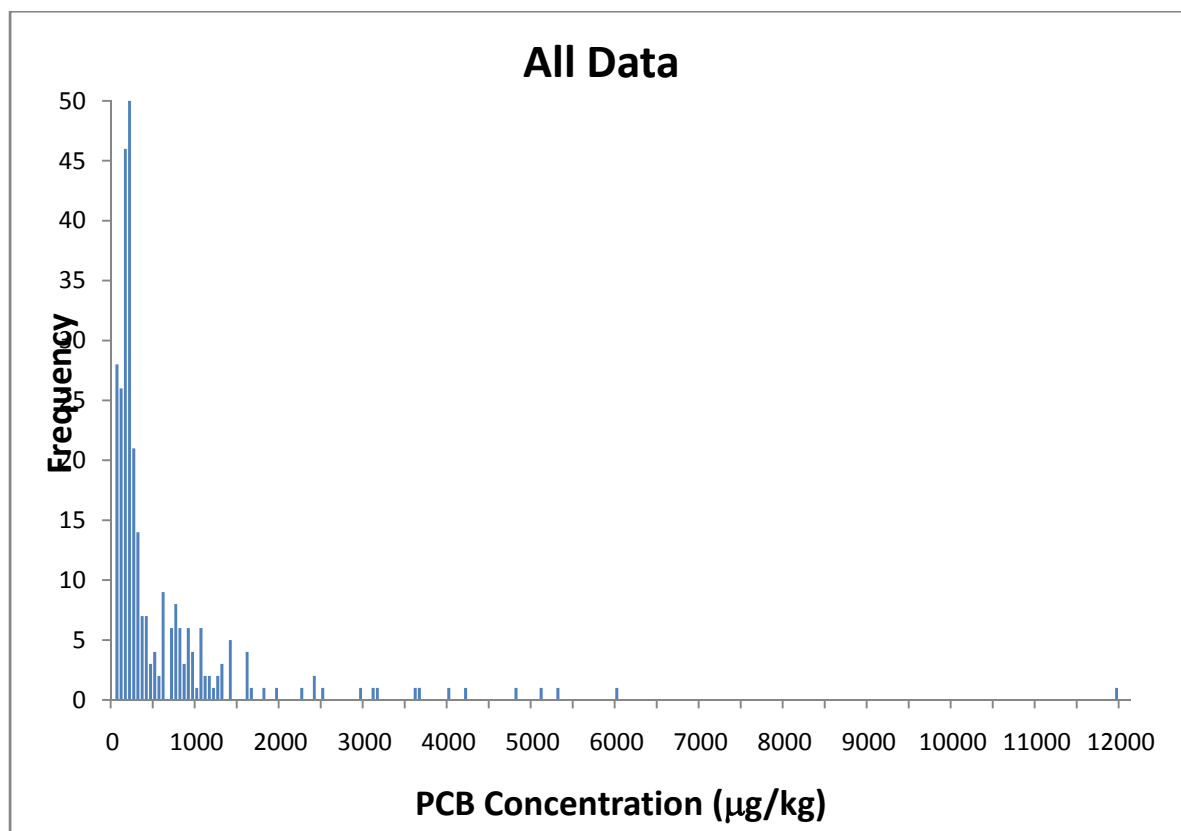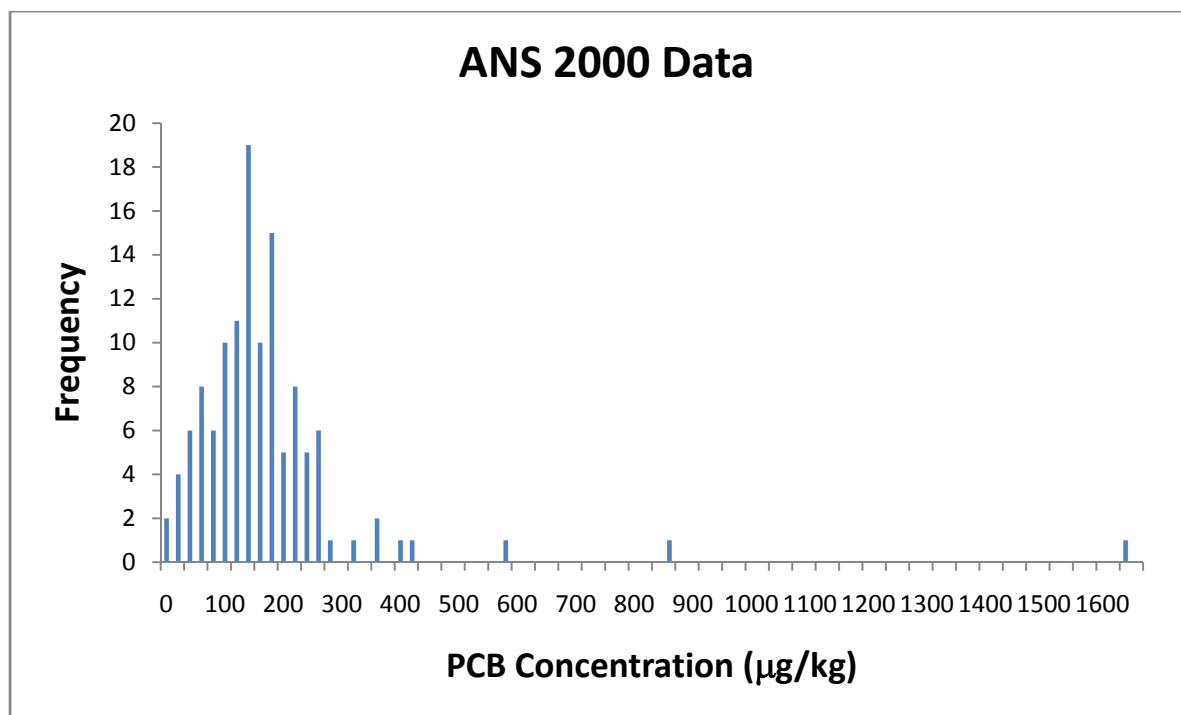
Figure 3 Maps of PCBs in the Anacostia River

Figure 4 Maps of PAHs in the Anacostia River
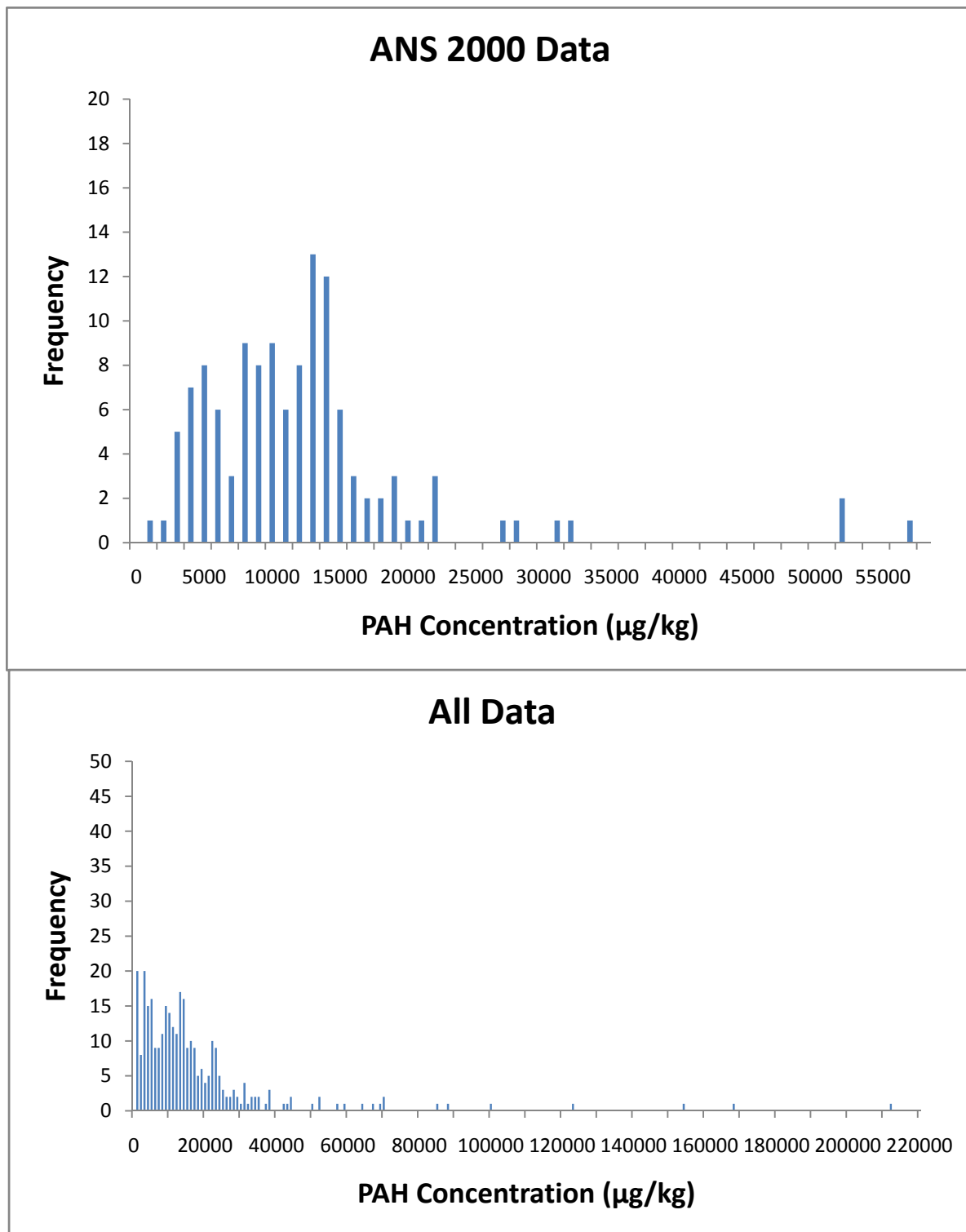
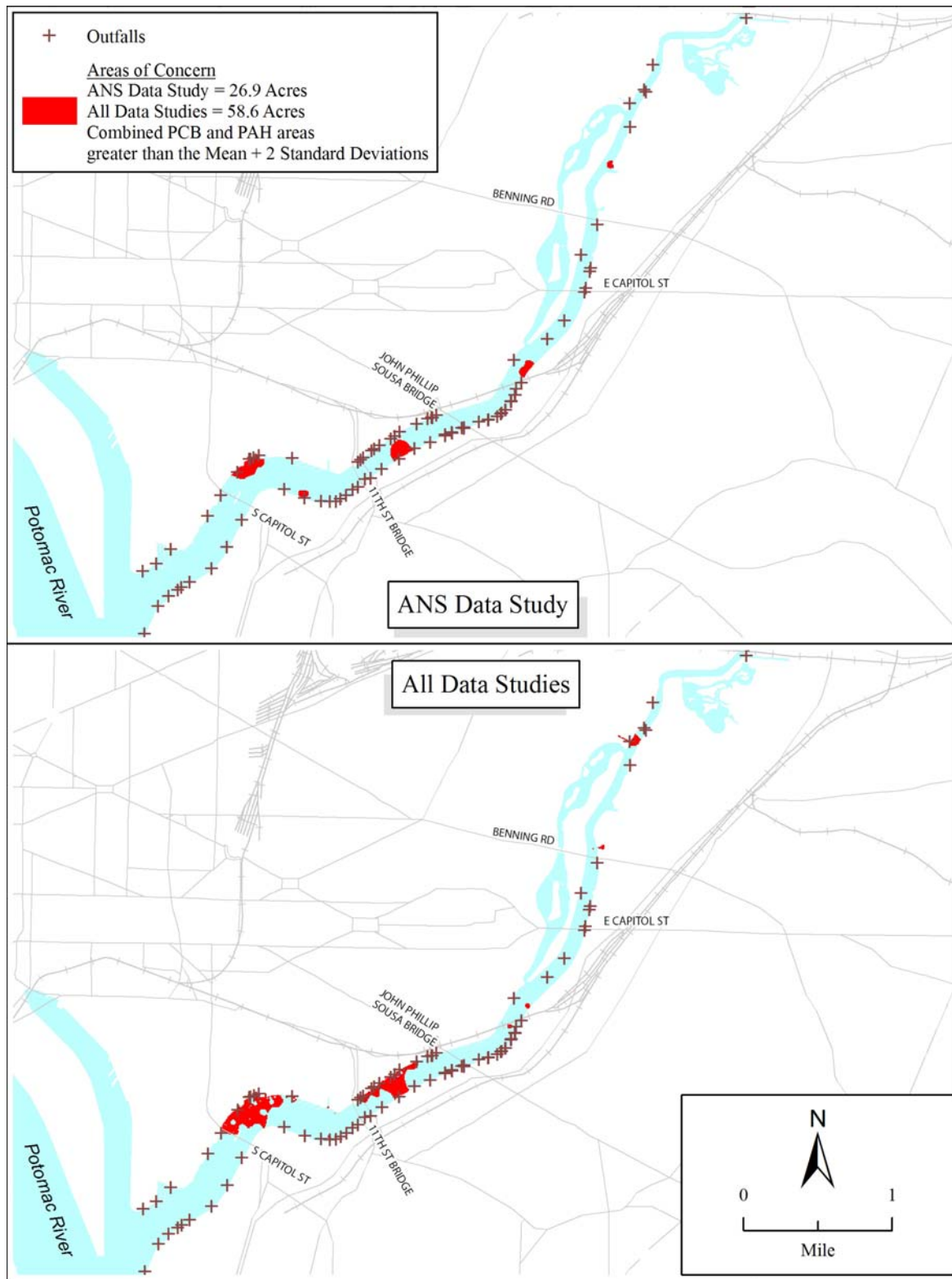**Figure 5 Histograms of PCBs**

Figure 6 Histogram of PAHs

Figure 7 Map of PCB and PAH hotspots in the Anacostia River